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SEMI-ANNUAL PROGRESS REPORT

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COMPUTATION OF BROADBAND MIXING NOISE FROM TUBOMACHINERY

PERIOD COVERED BY THIS REPORT

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Papers (supported by the grant) accepted or submitted for publications are:

1. "Discretization errors inherent in finite difference solution of propeller noise problems" to appear in the AIAA Journal, 1992.

2. "Radiation boundary condition and anisotropy correction for the Helmholtz equation" submitted to the Journal of Computational Physics.

SIGNIFICANT RESULTS

Most current CFD schemes are designed for time independent calculations. Although many of these algorithms are nominally time marching methods, the time stepping part is usually no more than an iterative process towards a steady state solution. With few exceptions CFD schemes are numerically dispersive, dissipative and often anisotropic. Because of these attributes they are generally not suitable for computing acoustics problems. Furthermore, none of the well-known CFD methods can *guarantee that* the computed acoustic waves propagate with the correct speed of sound.

We have now developed a high order explicit time marching finite difference scheme for computational acoustics. The novelty of this scheme is that the finite difference approximation is not carried out in the usual way; i.e., by Taylor series truncation. Instead, it is determined in the wave number and frequency space. Further, the dispersion relation of the finite difference scheme is the same as that of the Euler equations (for waves with wavelengths longer than five mesh spacings). In these ways the global wave propagation characteristics of the finite difference equations are almost identical to those of the Euler equations. What this means is that the computed acoustic wave solution would be essentially non-dispersive, non-dissipative and isotropic. The correct acoustic wave speed is assured.

A set of radiation boundary conditions compatible with the high order finite difference scheme has also been developed. These radiation boundary conditions allow the acoustic disturbances to propagate out of the computation domain with minimal reflections. The above stated properties of the high order finite difference scheme and radiation boundary conditions are confirmed in an extensive series of computer test runs. We believe that our results represent a major breakthrough in computational acoustics.

The above results will be reported in an invited paper entitled "A Dispersion-Relation-Preserving Scheme for Computational Acoustics" at the forthcoming 14th AIAA Aeroacoustics Conference, May 1992.